

WHAT IS CLAIMED IS:

1. An ion beam apparatus comprising:

a scanner which scans an injected ion beam around a given scan center within a given scan surface; and

5 an electrostatic deflector which electrostatically deflects the ion beam ejected from the scanner through  $90^\circ$  so that an ion beam of desired energy travels in a direction perpendicular to the scan surface within a circular-arc-shaped deflection zone centered on the scan center.

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2. The ion beam apparatus comprising:

an ion source which extracts an ion beam;

a mass separation electromagnet which separates an ion beam of desired mass from the ion beam extracted from the ion source;

15 a scanner which scans the ion beam that has been passed through the mass separation electromagnet around a given scan center within a given scan surface;

an electrostatic deflector which electrostatically deflects the ion beam ejected from the scanner through  $90^\circ$  so that an ion beam  
20 of desired energy travels in a direction perpendicular to the scan surface within a circular-arc-shaped deflection zone centered on the scan center; and

a scanning mechanism which retains a target for ion implantation and which mechanically, reciprocally moves the target in a direction

25 in which the target crosses the ion beam ejected from the electrostatic

deflector at a given angle.

3. The ion beam apparatus according to claim 2, wherein  
said scanning mechanism moves said target in a direction parallel  
5 to a surface of said target.

4. The ion beam apparatus according to any one of claims  
1 to 3, wherein said electrostatic deflector has a pair of deflection  
electrodes which are spaced apart from each other and mutually oppose.

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5. The ion beam apparatus according to claim 4, wherein,  
provided that three axes intersecting at right angles at one point  
are taken as X, Y and Z axes,

said ion beam is injected into said scanner in parallel to  
15 said Z axis;

said scanner which scans said injected ion beam with said scan  
center as a center within said scan surface parallel to a Y-Z plane;  
and

said electrostatic deflector which deflects an ion beam of  
20 desired energy in said injected ion beam through  $90^\circ$  so as to eject  
in parallel with said X axis;

when consideration is given of a locus of one ion beam having  
desired energy in said scanned and deflected ion beam, said locus  
assumes the shape of an arc-shaped section at an extremity of a linear  
25 section, said arc-shaped section being bent in the manner of an arc

at an angle of  $90^\circ$  so as to become parallel to said X axis; and  
mutually-opposing surfaces of a pair of deflection electrodes  
constituting said electrostatic deflector each have a shape generally  
aligned with a surface of revolution, said surface of revolution  
5 being drawn by said arc-shaped section when said locus of one ion  
beam is rotated through a predetermined angle in said scanning  
direction with reference to an axis passing through said scan center  
and parallel to said X axis.

10           6.       The ion beam apparatus according to claim 5, wherein  
said mutually-opposing surfaces of said respective deflection  
electrodes constituting said deflection electrode each assume a shape  
defined by means of circumferentially cutting a torus through a  
predetermined angle centered on a torus center axis which passes  
15 through the scan center and is parallel to the X axis, and cutting  
an outer periphery of a longitudinal cross-sectional surface of said  
torus through only  $90^\circ$ .

20           7.       The ion beam apparatus according to claim 5 or claim  
6, wherein said mutually-opposing surfaces of said pair of deflection  
electrodes constituting said deflection electrodes are each formed  
by combination of a plurality of surfaces aligned with said surface  
of revolution.

25           8.       The ion beam apparatus according to any one of claims

4 to 7, wherein at least one of said pair of deflection electrodes constituting said electrostatic deflector is divided into a plurality of segments with a gap in a direction in which a deflection angle is increased.

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9. The ion beam apparatus according to any one of claims 4 to 8, wherein at least said mutually-opposing surfaces of said pair of deflection electrodes constituting said electrostatic deflector are formed from carbon.

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10. The ion beam apparatus according to any one of claims 4 to 9, further comprising:

a deflection power source for applying a deflection voltage, which is a d.c. voltage and symmetrical with respect to a ground voltage, to said mutually-opposing surfaces of said pair of deflection electrodes constituting said electrostatic deflector.

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11. The ion beam apparatus according to any one of claims 1 to 10, wherein said scanner scans said ion beam that has injected into said scanner in a symmetrical manner with respect to an incident axis of said ion beam.

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12. The ion beam apparatus according to any one of claims 1 to 10, wherein said scanner scans said ion beam that has injected into said scanner in only an area on one side with respect to an

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incident axis of said ion beam.

13. The ion beam apparatus according to any one of claims 1 to 12, further comprising:

5 an acceleration/deceleration device which is interposed between said scanner and said electrostatic deflector and electrostatically accelerates or decelerates said scanned ion beam, wherein said acceleration/deceleration device has at least two electrodes spaced a given interval in a traveling direction of  
10 said ion beam; and

each of said electrodes has a circular-arc shape centered on said scan center, and a beam passage hole which is wider than said scanned ion beam in said scanning direction.

15 14. The ion beam apparatus according to claim 13, wherein an entrance electrode constituting said acceleration/deceleration device also serves as an analysis slit which permits passage of an ion beam of desired mass and inhibits passage of ions of undesired mass.

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15. The ion beam apparatus according to any one of claims 1 to 14, wherein a beam mask which permits passage of an ion beam of desired energy and inhibits passage of ions of undesired energy is disposed in the vicinity of an exit of said electrostatic deflector.

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16. The ion beam apparatus according to claim 15, wherein  
a scanned beam cross section of said ion beam passed from said  
electrostatic deflector, the scanned beam cross section  
perpendicular to a traveling direction of said ion beam, assumes  
5 the shape of an arc, and said beam mask has a beam passage hole having  
an arc-shaped geometry substantially similar to said arc-shaped  
scanned beam cross section.

17. The ion beam apparatus according to any one of claims  
10 1 to 16, wherein said scanner has a pair of mutually-parallel scan  
electrodes, and a scan power source which applies a scan voltage  
 $V_s$  expressed by  $V_s = ct/(1-c^2t^2)^{1/2}$  ("c" is a constant, and "t" is  
time) between said pair of scan electrodes.

15 18. The ion beam apparatus according to any one of claims  
1 to 3, wherein an entrance potential of said electrostatic deflector  
is lower than an exit potential of the same; and

said electrostatic deflector decelerates said ion beam of  
desired energy among said ion beam that has injected into said  
20 electrostatic deflector while deflecting said ion beam in the manner  
mentioned previously.

19. The ion beam apparatus according to any one of claims  
1 to 3, wherein an entrance potential of said electrostatic deflector  
25 is higher than an exit potential of the same; and

said electrostatic deflector accelerates said ion beam of desired energy among said ion beams that has injected into said electrostatic deflector while deflecting said ion beam in the manner mentioned previously.

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20. The ion beam apparatus according claim 18, wherein said electrostatic deflector has inner and outer deflection electrodes which oppose each other with an interval therebetween; and

10 said interval between said mutually-opposing surfaces of said inner and outer deflection electrodes becomes wider toward said exit of said deflector.

21. The ion beam apparatus according to claim 19, wherein said electrostatic deflector has inner and outer deflection  
15 electrodes which oppose each other with an interval therebetween; and

said interval between said mutually-opposing surfaces of said inner and outer deflection electrodes becomes narrower toward said exit of said deflector.

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22. The ion beam apparatus according claim 18, wherein the following relationships are satisfied on condition that said electrostatic deflector has inner and outer deflection electrodes which oppose each other with an interval therebetween; that said

25 inner and outer deflection electrodes are divided into "n" pairs

("n" is an integer of two or more) in a direction in which said deflection angles increase, to thus form "n" deflection electrode pairs; that voltages applied to said inner deflection electrodes among said "n" deflection electrode pairs are taken as  $V_{a_1}, V_{a_2}, \dots, V_{a_n}$  in sequence from said entrance; and that voltages applied to said outer deflection electrodes among said "n" deflection electrode pairs are taken as  $V_{b_1}, V_{b_2}, \dots, V_{b_n}$  in sequence from said entrance,

$$V_{a_1} < V_{a_2} < \dots < V_{a_n},$$

$$V_{b_1} < V_{b_2} < \dots < V_{b_n}, \text{ and}$$

$$V_{a_1} < V_{b_1}, V_{a_2} < V_{b_2}, \dots, V_{a_n} < V_{b_n}.$$

23. The ion beam apparatus according claim 19, wherein the following relationships are satisfied on condition that said electrostatic deflector has inner and outer deflection electrodes which oppose each other with an interval therebetween; that said inner and outer deflection electrodes are divided into "n" pairs ("n" is an integer of two or more) in a direction in which said deflection angles increase, to thus form "n" deflection electrode pairs; that voltages applied to said inner deflection electrodes among said "n" deflection electrode pairs are taken as  $V_{a_1}, V_{a_2}, \dots, V_{a_n}$  in sequence from said entrance; and that voltages applied to said outer deflection electrodes among said "n" deflection electrode pairs are taken as  $V_{b_1}, V_{b_2}, \dots, V_{b_n}$  in sequence from said entrance,

$$V_{a_1} > V_{a_2} > \dots > V_{a_n},$$

$$V_{b_1} > V_{b_2} > \dots > V_{b_n}, \text{ and}$$



$$Va_1 < Vb_1, Va_2 < Vb_2, \dots, Va_n < Vb_n.$$

24. The ion beam apparatus according claim 22 or claim 23,  
 wherein said interval between said mutually-opposing surfaces of  
 5 said respective "n" deflection electrode pairs is constant from said  
 entrance to said exit of said electrostatic deflector.

25. The ion beam apparatus according claim 22, wherein said  
 interval between said mutually-opposing surfaces in said respective  
 10 "n" deflection electrode pairs becomes wider toward said exit of  
 said deflector.

26. The ion beam apparatus according claim 23, wherein said  
 interval between said mutually-opposing surfaces in said respective  
 15 "n" deflection electrode pairs becomes narrower toward said exit  
 of said deflector.

27. The ion beam apparatus according claim 18 or claim 19,  
 wherein the following expressions or equivalent mathematical  
 20 relationships are substantially satisfied on condition that said  
 electrostatic deflector has inner and outer deflection electrodes  
 which oppose each other with an interval therebetween; that radii  
 of mutually-opposing surfaces of said inner and outer deflection  
 electrodes are taken as  $r_a$  and  $r_b$ ; that voltages applied to said  
 25 inner and outer deflection electrodes are taken as  $V_a$  and  $V_b$ ; an

electric potential in an orbit of said ion beam of desired energy within said electrostatic deflector is taken as  $V$ ; a voltage corresponding to said ion beam of kinetic energy at said exit of said electrostatic deflector is taken as  $V_e$ ; and a design orbit radius of said ion beam within said electrostatic deflector is taken as  $r_c$ ;

$$V_a = V - 2(V_e - V) \log(r_c/r_a), \text{ and}$$

$$V_b = V + 2(V_e - V) \log(r_b/r_c).$$